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CONTROL OF GOOSEBERRY DISEASES

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ABSTRACT

THE three major diseases of gooseberries in New York State are powdery mildew, *Sphaerotheca mors-uvae* (Schw.) Berk. and Curt.; leaf spot, *Mycosphaerella grossulariae* (Fr.) Lindau, and *Pseudopeziza ribis* Kleb.; and rust, *Puccinia grossulariae* (Schum.) Lagh. Powdery mildew and leaf spot are generally prevalent thruout the State, while rust occurs in the Hudson Valley region.

Experiments on the control of these three diseases were conducted from 1937 to 1944, inclusive. Spray tests showed that only one application of lime-sulfur, 2–100, plus ½ pound Spraysoy A, made immediately after bloom, gave effective control of powdery mildew. In most years, copper fungicides also gave control but were not effective during a dry season. Two applications of a 3–5–100 bordeaux mixture, plus 1 pint of S.E.C. oil, the first made 2 or 3 weeks after bloom and the second after harvest, gave superior control of leaf spot.

Of the 11 insoluble coppers tested, Yellow Cuprocide plus lime at 1–4–100 with 1 pint of S.E.C. oil was best but not as good as the bordeaux.

Copper injury occurred to the gooseberry foliage and was prevented by the use of a 3–5–100 bordeaux or the addition of 1 pound of lime for each ¼ pound of actual copper in the insoluble copper fungicides.

Rust was controlled by the eradication or burning-over of sedge areas adjacent to the gooseberry planting or by spraying. Spray tests showed that for effective control of rust, three applications of lime-sulfur, 2–100, were required. The first application was made at the green-tip stage, the second about 10 days later, and the third just before bloom.

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CONTROL OF GOOSEBERRY DISEASES

R. F. SUIT and D. H. PALMITER

INTRODUCTION

There are three diseases of gooseberries which at times become the limiting factor in gooseberry production. Recently the question of diversification of fruit crops has become of importance, particularly in the Hudson Valley. While some gooseberries are grown in other parts of the State, a greater acreage of gooseberries was grown in the Hudson Valley in previous years. If the diseases could be satisfactorily controlled, it would aid greatly in reviving the interest in gooseberry culture.

Powdery mildew, *Sphaerotheca mors-uvae* (Schw.) Berk. and Curt., is the most important of the three diseases. This disease causes a brown, felt-like covering of mildew on the fruit, especially on the English-type gooseberries, which makes the fruit unsalable, altho the fruit does not rot but tends to dry up (Fig. 1). The mildew also attacks the leaves and canes (Figs. 2 and 3) and causes stunting.

Leaf spot caused by *Mycosphaerella grossulariae* (Fr.) Lindau or *Pseudopeziza ribis* Kleb., of which the former is the most prevalent, is universally present in the State. The premature defoliation of the bushes by leaf spot weakens them so that they do not produce a normal crop and are more subject to winter injury.

Rust, *Puccinia grossulariae* (Schum.) Lagh., has caused serious loss of both fruit and foliage, especially in the Hudson Valley where plantings were located near fields of certain wild sedge plants on which the fungus lives over winter. This rust may be recognized by the presence of bright orange-colored cups grouped on reddish, swollen areas on the lower surface of the gooseberry leaves in early spring (Fig. 4). The fruit also may be infected (Fig. 5). Diseased fruits are not salable and may rot and fall off before harvest due to secondary fungi. The presence of two or more lesions per leaf may cause defoliation soon after bloom, thus reducing the size and quality of the fruit and lowering the general vigor of the plant.

Altho there was a suggested spray schedule (5)[1] for the control of powdery mildew and leaf spot, the majority of the growers were not

[1]Figures in parenthesis refer to Literature Cited, page 21.

FIG. 1.—POWDERY MILDEW ON THE FRUIT OF ENGLISH-TYPE GOOSEBERRIES.
Note felt-like covering of mildew on the fruit which makes it unsalable.

inclined to use it. Gooseberries, being a minor crop, did not warrant the expenditure of considerable time and money for the control of diseases. Consequently, the gooseberry plantings were removed if diseases became troublesome. The principal objections to the suggested spray schedule were the number of applications recommended and the fact that lime-sulfur did not give a satisfactory control of leaf spot. If the 8–8–100 bordeaux mixture was used for leaf-spot control, the spray residue on the berries was objectionable. A satisfactory method of control for the rust had not been developed.

In 1937, experiments were initiated to develop a suitable program for the control of the rust disease. The investigations leading to a revision of the spray schedules for the control of powdery mildew and leaf spot were started in 1939. Since that time, preliminary reports on the progress of the work on the control of powdery mildew and leaf spot have been presented (11, 12, 13). Following the presentation of these reports, the suggested spray schedules for the control of powdery mildew and leaf spot were revised (9).

This bulletin gives the results of experiments conducted in the Hudson Valley and in western New York since 1937 on the development of efficient and economical spray schedules for the control of the three major diseases of gooseberries.

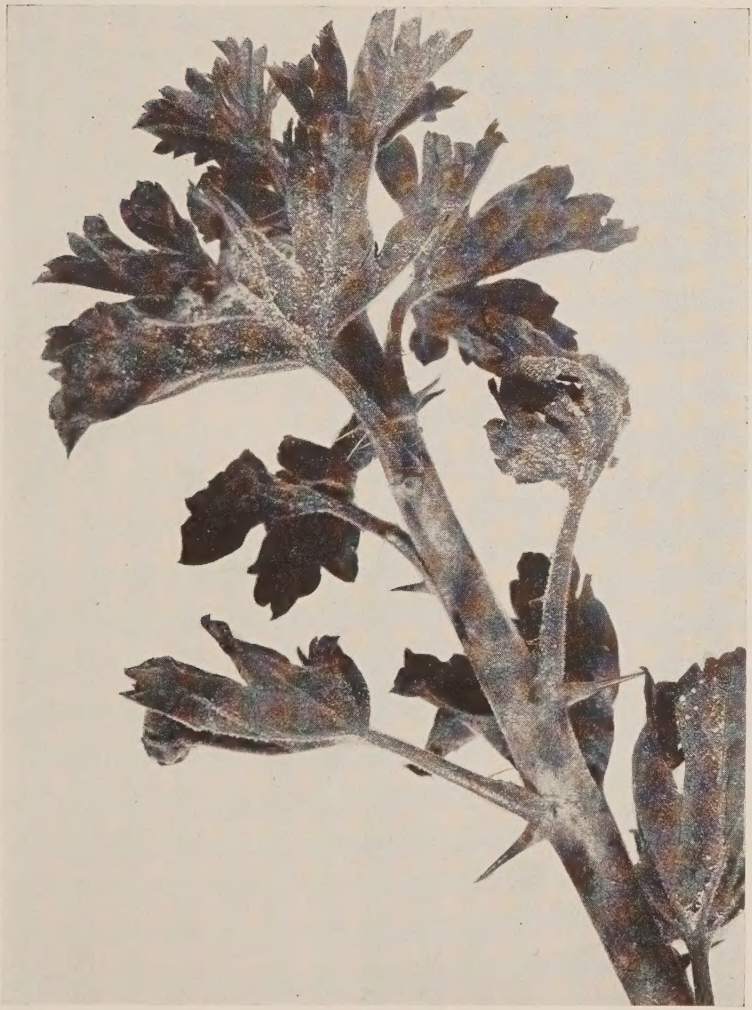

FIG. 2.—POWDERY MILDEW ON THE LEAVES AND STEM OF A YOUNG GOOSEBERRY CANE.
Note dwarfing and distortion.

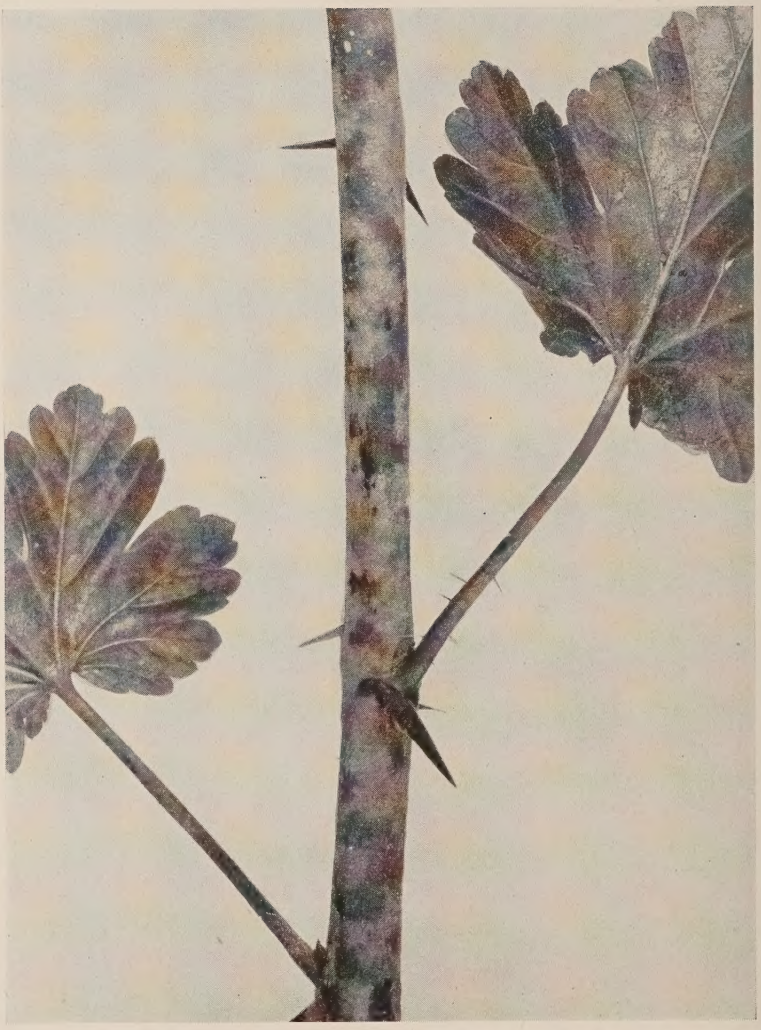

FIG. 3.—POWDERY MILDEW LESIONS ON A GOOSEBERRY CANE.
The perithecia which live over winter are produced in these lesions.

FIG. 4.—CLUSTER-CUP RUST LESIONS ON UPPER (LEFT) AND LOWER SURFACES (RIGHT) OF GOOSEBERRY LEAVES.

Aeciospores are produced in the cups on the lower surface.

FIG. 5.—RUST LESIONS ON GOOSEBERRY FRUIT.

THE CAUSAL FUNGI

A brief discussion of the life cycles of the fungi which cause the three diseases will give a better understanding of the nature of the disease in question and the reason why fungicides should be applied at certain times.

Sphaerotheca mors-uvae, which causes powdery mildew, forms the overwintering perithecia in the mycelium on the canes (Fig. 3) during

July. These perithecia remain dormant on the canes over winter. In the spring, usually during the first part of May, just after the gooseberries have set fruit, the perithecia produce ascospores which cause the primary infection on the young fruit and leaves. Within 10 days, the infection has developed and is producing conidia which spread the disease to other leaves and fruit. In a very short time, the disease has spread thruout the planting. Obviously, sprays should be applied in the spring to control the primary infection, and thus eliminate the secondary infection.

The life cycles of *Mycosphaerella grossulariae* and *Pseudopeziza ribis* which cause leaf spot are practically identical, except that different types of spores are present. Gooseberry leaves which have become diseased drop to the ground where the fungus remains dormant during the winter. In the spring, usually between May 15 and June 1, fruiting bodies which produce ascospores are formed. These ascospores infect the leaves, causing the primary leaf-spot infection. After a short period of time, conidia are produced in the diseased spots. These conidia are spread by wind and rain to other leaves and before long the leaves are infected and the bushes are defoliated. If the primary infection could be prevented, the leaf spot would be eliminated.

FIG. 6.—SEDGE ON WHICH RUST FUNGUS LIVES OVER WINTER.

Gooseberry rust, caused by *Puccinia grossulariae,* cannot spread from gooseberry to gooseberry. This fungus has a complicated life cycle, part of which is spent on the gooseberry and the other part on grass-like sedge plants. Under New York conditions, aeciospores from the orange-colored cups on the diseased gooseberry fruits and leaves are blown to sedge plants (Fig. 6) which become infected and show typical uredinal rust lesions on the leaves during June and July. The uredospores can infect other sedge plants but not gooseberries. Later in the season, teliospores are produced in the same or different lesions (Fig. 7). These spores live over winter on the old sedge leaves and in the spring germinate and produce sporidia which are blown to the gooseberry plants where, under favorable conditions, infection occurs. Rust spots become visible on the gooseberry leaves within 2 weeks after infection. About 3 weeks later aeciospores are produced, thus completing the life cycle. The elimination of the overwintering teliospores or the application of early sprays to the gooseberries should be possible methods of control.

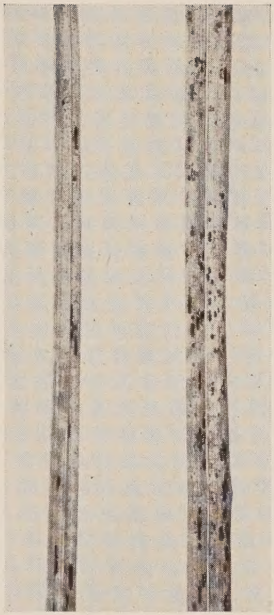

FIG. 7.—TELIOSPORE LESIONS ON SEDGE LEAVES.

EXPERIMENTAL RESULTS

POWDERY MILDEW CONTROL

From 1939 to 1944, experiments were conducted to determine the number of applications required for effective control of powdery mildew, their relative importance, and what fungicides would be satisfactory. Field plots were sprayed with a power sprayer at 300 pounds pressure.

The relative importance of the different spray applications was determined in the 1939 tests. Lime-sulfur, 1–10, and Elgetol, 1–100, were tested for their possible effectiveness in killing the overwintering perithecia, while lime-sulfur, 2–100, and Cuprocide 54–Y, 1½–100, were used for the cover-spray applications. Two grades of Elgetol and

lime-sulfur gave very good control of powdery mildew when applied at the green-tip stage (Table 1). The sprays applied at the four-leaf stage only were as effective as the more concentrated sprays applied at the green-tip stage. Those sprays which were applied after bloom only were the most effective when single applications were compared (Table 1). If all three applications were made to the same plot, the control was not significantly better than the results obtained with the after-bloom application only. Lime-sulfur, 2–100, or Cuprocide 54–Y, 1½–100, plus 1 pint of S.E.C. oil, was equally satisfactory for mildew control in the four-leaf and after-bloom applications (Table 1). S.E.C. oil alone has some toxicity to powdery mildew. Two applications of ½ per cent S.E.C. oil allowed only 11.8 per cent diseased berries (Table 1). It can be concluded from this experiment that the after-bloom application is the most important.

Since the control of powdery mildew in 1939 was as effective with a copper fungicide as it was with lime-sulfur, the tests in 1940 were concerned with the relative efficiency of various copper fungicides for disease control. At farm No. 1, an after-bloom application of lime-sulfur, 2–100; Coposil, 2–100; Basicop, 2–100; Cuprocide 54–Y, 1½–100; or Yellow Cuprocide, 1–100, gave equally good control of powdery mildew (Table 2). Bordeaux mixture and Copper Compound A were not as effective but gave satisfactory control. At farm No. 2, the after-bloom application was about a week late. While the disease control was good (Table 2), it apparently was not what would have been obtained if the application had been timed correctly.

All of the copper materials caused injury to the leaves which appeared as a russeting on the under side. Bordeaux mixture, Bordow, and Coposil were the least injurious (Table 2), while Cuprocide 54–Y and Yellow Cuprocide showed the most injury.

In the experiments conducted in 1939 and 1940, S.E.C. oil was added to the copper fungicides as a spreader-sticker. Copper injury was first observed in the 1940 tests. The tests conducted in 1941 were planned to determine if the S.E.C. oil were necessary for effective disease control and if the copper injury could be eliminated. The addition of S.E.C. oil to lime-sulfur, 2–100, did not increase the control of powdery mildew (Table 3), but when it was added to the copper fungicides, a significant reduction in the percentage of diseased berries resulted. The addition of 1 pound of lime for each ¼ pound of actual copper in the insoluble coppers effectively controlled the copper injury. A 3–5–100 formula of bordeaux mixture also was satisfactory for

TABLE 1.—RESULTS OF SPRAY TESTS FOR CONTROL OF POWDERY MILDEW AND LEAF SPOT ON GOOSEBERRIES, 1939.

SPRAYS APPLIED*			POWDERY MILDEW, PER CENT DISEASED BERRIES, JUNE 26	LEAF SPOT, PER CENT DEFOLIATION, SEPT. 22
Green-tip, Apr. 21	Four-leaf, May 4	After-bloom, May 19		
None	None	None	96.5	100
None	S.E.C. oil, 2 qt.–100	None	23.8	—
None	S.E.C. oil, 2 qt.–100	S.E.C. oil, 2 qt.–100	11.8	—
None	Lime–sulfur, 2–100	None	4.6	96
None	Lime–sulfur, 2–100	Lime-sulfur, 2–100	0.3	92
None	None	Lime-sulfur, 2–100	0.4	94
None	Cuprocide 54-Y, 1½–100	None	4.0	92
None	Cuprocide 54-Y, 1½–100	Cuprocide 54-Y, 1½–100	0.7	68
None	None	Cuprocide 54-Y, 1½–100	0.5	60
Lime-sulfur, 1–10	None	None	5.8	94
Lime-sulfur, 1–10	Lime-sulfur, 2–100	None	2.1	94
Lime-sulfur, 1–10	Lime-sulfur, 2–100	Lime-sulfur, 2–100	0.4	94
Lime-sulfur, 1–10	None	Lime-sulfur, 2–100	0.9	96
Lime-sulfur, 1–10	Cuprocide 54-Y, 1½–100	None	1.7	96
Lime-sulfur, 1–10	Cuprocide 54-Y, 1½–100	Cuprocide 54-Y, 1½–100	1.4	74
Elgetol, 1–100	None	None	6.5	90
Elgetol, 1–100	Lime-sulfur, 2–100	None	2.9	90
Elgetol, 1–100	Lime-sulfur, 2–100	Lime-sulfur, 2–100	0.3	98
Elgetol, 1–100	None	Lime-sulfur, 2–100	0.1	96
Elgetol, 1–100†	None	None	2.2	92
Elgetol, 1–100†	Lime-sulfur, 2–100	None	1.5	94
Elgetol, 1–100†	Lime-sulfur, 2–100	Lime-sulfur, 2–100	0.2	96
Elgetol, 1–100†	None	Lime-sulfur, 2–100	0.3	94
Elgetol, 1–100†	Cuprocide 54-Y, 1½–100	None	1.8	80
Elgetol, 1–100†	Cuprocide 54-Y, 1½–100	Cuprocide 54-Y, 1½–100	0.1	68
Minimum significant difference (19:1)			1.4	4.6

*S.E.C. oil (self-emulsifying cottonseed oil), 1 pint — 100 gallons, added to all Cuprocide 54–Y sprays.
†This material was labeled Elgetol, Special Penetrant.

TABLE 2. EFFICIENCY OF FUNGICIDES FOR THE CONTROL OF POWDERY MILDEW AND LEAF SPOT ON GOOSEBERRIES, 1940.

FUNGICIDES*	COPPER INJURY†		POWDERY MILDEW, PER CENT DISEASED BERRIES		LEAF SPOT, PER CENT DEFOLIATION	
	Farm No. 1, June 20	Farm No. 2, July 1	Farm No. 1, June 20	Farm No. 2, July 1	Farm No. 1, Sept. 27	Farm No. 2, Oct. 10
None	0	0	100.0	100.0	100	100
Lime-sulfur, 2–100	0	0	0.5	2.4	100	100
Coposil, 2–100	+	+	1.0	2.5	72	94
Tennessee 34, 2–100	–	+++	—	3.1	—	85
Basicop, 2–100	++	++	0.8	7.5	64	86
Bordow, 4–100	–	+	—	8.2	—	72
Copper Compound A, 2–100	++	+	1.9	7.3	78	88
Cuprocide 54-Y, 1½–100	++++	+++	0.7	4.2	58	74
Yellow Cuprocide, 1–100	++++	++++	0.7	6.6	56	73
Bordeaux mixture, 8–8–100	+	+	3.0	12.3	42	64
Bordeaux mixture, 3–3–100	+	+	2.4	8.1	52	70
Minimum significant difference (19:1)			0.78	0.73	4.6	7.8

*Dates of application were as follows: Farm No. 1 (Hudson Valley), May 21 and July 25; farm No. 2 (western New York), May 28 and July 17. S.E.C. oil, 1 pint 100 gallon, was added to all sprays except lime-sulfur. For second application, lime, 4 100, was added to all insoluble coppers.

†Copper injury was scored as follows: +, trace; ++, slight; +++, moderate; ++++, severe.

control of copper injury. Fermate was not satisfactory for the control of powdery mildew (Table 3).

TABLE 3.—EFFICIENCY OF FUNGICIDES FOR THE CONTROL OF POWDERY MILDEW AND LEAF SPOT ON GOOSEBERRIES, 1941.

FUNGICIDE*	S.E.C. OIL ADDED	POWDERY MILDEW, PER CENT DISEASED BERRIES, JUNE 30	LEAF SPOT, PER CENT DEFOLIATION, SEPT. 17
None	——	100.0	100
Lime-sulfur, 2–100	None	1.6	100
Lime-sulfur, 2–100	1 pint	1.4	100
Lime-sulfur, first, 2–100 Bordeaux mixture, second, 6–10–100	None	1.8	73
Lime-sulfur, first, 2–100 Bordeaux mixture, second, 6–10–100	1 pint	1.5	58
Yellow Cuprocide, 1–4–100	None	75.0	59
Yellow Cuprocide, 1–4–100	1 pint	55.0	33
Bordeaux mixture, 3–5–100	None	80.0	49
Bordeaux mixture, 3–5–100	1 pint	35.0	34
Fermate, 2–1–100	None	75.0	100
Fermate, 2–1–100	1 pint	50.0	91
Tribasic copper sulfate, 2–4–100	None	75.0	92
Tribasic copper sulfate, 2–4–100	1 pint	65.0	55
Copper oxychloride, 2–4–100	None	65.0	74
Copper oxychloride, 2–4–100	1 pint	50.0	47
Copper oxychloride-sulfate, 2–4–100	None	65.0	90
Copper oxychloride-sulfate, 2–4–100	1 pint	50.0	57
Minimum significant difference (19:1)		9.1	3.7

*Dates of application: May 12 and July 22, 1941. The second number in the formulae for the copper fungicides is the number of pounds of lime.

In the 1941 tests, all of the copper fungicides gave very poor control of powdery mildew, while lime-sulfur, 2–100, showed only 1.6 per cent diseased berries (Table 3). This failure of the copper fungicides to control the disease is not in accord with the results obtained in 1939 and 1940 when the copper fungicides were as effective as the lime-sulfur. In 1939 and 1940, rain periods occurred between the time that the bushes were sprayed and when the disease first appeared. During 1941, there was no rain from the time that the bushes were sprayed until the disease first appeared. Apparently, the copper fungicides were not effective when rain did not occur between the time the sprays were applied and the first appearance of the disease, while the lime-sulfur was able to control the disease effectively in both wet and dry seasons.

The effectiveness of an after-bloom application of lime-sulfur, 2–100, was tested on a semi-commercial scale during 1942, 1943, and 1944.

Spraysoy A, ½–100, was added to the lime-sulfur to give a better coverage. During the 3 years, the nonsprayed plot always showed 100 per cent of the berries diseased, while the sprayed block showed 0.5, 1.0, and 0.2 per cent diseased berries, respectively.

LEAF-SPOT CONTROL

In connection with the experiments on the control of powdery mildew, tests were conducted to determine an effective spray program for the control of leaf spot. The percentage of defoliation by leaf spot that occurred in the various plots was obtained by the same method as that previously used for currant leaf spot (14).

Altho the data obtained in 1939 do not show a high degree of control of leaf spot since no sprays were applied after May 19, they do indicate that a copper fungicide was more effective for disease control than lime-sulfur (Table 1).

Since an early application of the fungicide was not sufficient to control the leaf spot, a second application was made to the plots in 1940 after the fruit was harvested. If not more than 40 per cent defoliation had occurred by September 15, the control of leaf spot was considered satisfactory. After this date, the defoliation increases rapidly due to natural causes.

Suit (14) has shown that where leaf spot of currants was effectively controlled, the percentage of defoliation increased from 12 per cent on September 8 to 60 per cent on October 13. Those plots sprayed with lime-sulfur during 1940 were completely defoliated when the records were taken (Table 2). Bordeaux mixture, Yellow Cuprocide, Cuprocide 54–Y, and Bordow gave significantly better control of leaf spot than Coposil, Tennessee 34, and Copper Compound A (Table 2). The 8–8–100 bordeaux mixture gave better control than the 3–3–100 formula but caused an objectionable residue on the fruit (Table 2).

A combination of an after-bloom application and an after-harvest application of the fungicides was tested a second time in 1941 for the control of leaf spot. The effectiveness of S.E.C. oil as a spreader-sticker was also investigated. Again, lime-sulfur did not control leaf spot (Table 3), altho a split schedule of lime-sulfur after bloom and bordeaux mixture after harvest showed fair control. The best control obtained in 1941 was with Yellow Cuprocide and bordeaux mixture (Table 3). A significant decrease in the percentage of defoliation occurred when the S.E.C. oil was used as a spreader-sticker for the copper fungicides (Table 3). This fact also has been reported for the control

of currant leaf spot (14). Fermate did not give control of the leaf spot (Table 3).

During 1942, 1943, and 1944, a split schedule of one application of lime sulfur, 2–100, and two applications of bordeaux mixture, 3–5–100, plus 1 pint of S.E.C. oil, was tested on a semi-commercial scale for the control of leaf spot. The first application was made immediately after bloom, the second between June 5 and 10, and the third after the fruit was harvested. The exact dates of the first and third applications varied with the season. In all three years, the nonsprayed plot was completely defoliated by August 15. In the sprayed block, the percentage of defoliation on September 15 was 15.4, 10.1, and 21.4, respectively, for the 3 years during which the test was conducted.

RUST CONTROL

Eradication of alternate host.—The elimination of sedge plants from the vicinity of gooseberry plantings is the most commonly recommended method of controlling the cluster cup rust. The incidence of infection was greatly reduced in one planting when a nearby field containing infected sedge plants was drained and planted to cultivated crops. The actual killing of the sedge plants is not necessary since the rust spores on the old leaves can be destroyed by carefully burning the tops of the plants in the fall or early spring before the gooseberry buds open. This has greatly reduced the amount of rust infection where the sedge was in a field used for pasture.

Protection by fungicidal sprays.—Spray experiments were conducted in the field during 1937 and the two following seasons to determine which fungicides would effectively control this rust disease, how many applications were needed to afford commercial control, and which applications were more important. Randomized plots were sprayed with a power sprayer at 250 pounds pressure. Certain plots were left unsprayed thruout the season and others had one or two applications omitted to serve as checks for comparison with the sprayed plots.

In 1937, Camden flotation sulfur paste, 12–100; liquid lime sulfur, 2–100; bordeaux mixture, 4–6–100; and red copper oxide (Cuprocide 54) plus lime, 3–8–100, were compared. A total of four applications were made, starting April 20 when the first spur leaf was only ½ inch across. A second application was made April 26 when the fourth spur leaf was just opening; a third application, May 5 just before bloom;

and a fourth application, May 12 following bloom. Only flotation sulfur was used in the first application.

Each of the three pre-bloom applications was about equally important in controlling the rust (Table 4). All three applications were followed by rain periods favorable for infection. The post-bloom spray had no effect apparently because the source of inoculum was exhausted by the earlier rains.

TABLE 4.—EFFECTIVENESS OF VARIOUS FUNGICIDE APPLICATIONS FOR THE CONTROL OF CLUSTER-CUP RUST OF GOOSEBERRIES IN THE HUDSON VALLEY, 1937.

TREATMENTS AT STATED DATES			RUST LESIONS PER 100 SPURS
April 20	April 26	May 5	
None	None	None	35
Flotation sulfur paste, 12–100	Flotation sulfur paste, 12–100	Flotation sulfur paste, 12–100	1
Flotation sulfur paste, 12–100	Lime-sulfur, 2–100	Lime-sulfur, 2–100	1
Flotation sulfur paste, 12–100	Bordeaux, 4–6–100	Bordeaux, 4–6–100	1
Flotation sulfur paste, 12–100	Copper oxide, 3–8–100	Copper oxide, 3–8–100	7
None	Flotation sulfur paste, 12–100	Flotation sulfur paste, 12–100	7
Flotation sulfur paste, 12–100	None	Flotation sulfur paste, 12–100	7
Flotation sulfur paste, 12–100	Flotation sulfur paste, 12–100	None	6
None	Lime-sulfur, 2–100	Lime-sulfur, 2–100	11
None	Bordeaux, 4–6–100	Bordeaux, 4–6–100	10
None	Bordeaux, 4–6–100	None	13

The amount of infection this season was uniform but not heavy. Unsprayed plants averaged 35 rust lesions per 100 spurs (Table 4). Plants which received three early applications of flotation sulfur paste, lime-sulfur, or bordeaux mixture showed only a trace of rust. Red copper oxide was less effective. When flotation sulfur paste was used as the fungicide, the omission of the first, second, and third applications resulted in 7, 7, and 6 lesions per 100 spurs, respectively, compared with 35 lesions when all three applications were omitted and 1 lesion where all were made. Reduced schedules of lime-sulfur and bordeaux afforded less protection than the flotation sulfur paste.

The 1938 season was early and two applications of lime-sulfur, 2–100, made April 2 and 15 were sufficient to give adequate protection from rust, altho unsprayed plants averaged 35 per cent fruit infection

and had 21 per cent of the spur leaves infected (Table 5). A third spray applied April 23 was not needed since no infection periods occurred during the remainder of the month. In another planting, one application of lime-sulfur on April 2 allowed infection of 1 per cent of the fruit and 17 per cent of the spur leaves. One application on April 15 gave better control. This plot had no fruit infection and only 4 per cent of the spur leaves were infected. Where both the first and second sprays were applied, leaf infection was reduced to a trace. Plants receiving only the third application (April 21) showed as much infection as unsprayed plants with 4 per cent fruit infection and 36 per cent leaf infection (Table 5).

Host development in 1939 was 2 weeks later than in the previous year. Lime-sulfur applied April 15, 23, and May 2 reduced rust infection to a minimum (Table 5), but all three applications were necessary for complete control. In an experimental planting where gooseberry plants were artificially inoculated by placing sedge leaves bearing teliospores over the plants, two applications (April 14 and 26) of lime-sulfur failed to control the disease. The 12-day interval between applications was apparently too great to afford adequate protection for the rapidly expanding foliage under the conditions of heavy rainfall that occurred during this period.

DISCUSSION

Various spray schedules have been suggested for the control of powdery mildew and leaf spot on gooseberries (1, 2, 3, 4, 6, 7, 8, 10, 15), but no definite schedule was available for the control of rust. All of the suggested schedules listed lime-sulfur as the most effective fungicide for the control of powdery mildew, except that a copper fungicide was recommended (1) for use on varieties that are subject to sulfur injury. The number of applications of lime-sulfur varied from one to three. In all cases but two (7, 15), bordeaux mixture was recommended for the control of leaf spot. There was considerable variation in the suggested concentration of bordeaux mixture.

During the past 8 years, the experiments conducted in New York State have given additional information on the effective control of powdery mildew, leaf spot, and rust as they occur in this region.

All of the experimental work was conducted on the large-fruited, English-type gooseberries which are very susceptible to the three diseases. The Chautauqua was the principal variety on which the tests were made. Powdery mildew seldom occurs on the American-type

TABLE 5.—EFFECTIVENESS OF PRE-BLOOM APPLICATIONS OF LIME-SULFUR TO GOOSEBERRIES FOR RUST CONTROL IN THE HUDSON VALLEY.

YEAR	TREATMENTS AT STATED DATES			PERCENTAGE INFECTION	
1938*	April 2	April 15	April 23	Fruit	Foliage
	None	None	None	35	21
	Sulfur†	Sulfur	Sulfur	0	0
	Sulfur	Sulfur	None	0	0
1938‡	April 2	April 15	April 21		
	None	None	None	4	36
	Sulfur	Sulfur	Sulfur	0	1
	Sulfur	Sulfur	None	0	1
	Sulfur	None	None	1	17
	None	Sulfur	None	0	4
	None	None	Sulfur	4	36
1939‡	April 15	April 23	May 2		
	None	None	None	—	13
	Sulfur	Sulfur	Sulfur	—	0
	Sulfur	Sulfur	None	—	2
	Sulfur	None	Sulfur	—	1
	None	None	Sulfur	—	9
	Sulfur	None	None	—	5
1939	April 14		April 26		
	None		None	4	23
	Sulfur		Sulfur	1	21

*W. H. Brown planting, Marlboro, N. Y.
†Liquid lime-sulfur, 2–100, applied with power sprayer.
‡John Nicklin planting, Marlboro, N. Y.

gooseberries, but the leaf spot and rust may cause defoliation of the bushes.

The most important factor in the successful control of powdery mildew was the correct timing of the after-bloom application. This should be made as soon as the fruit has set. A delay of 1 week in applying this spray will result in a decided increase in the amount of mildew on the fruit. No increase in the control of mildew resulted from any of the fungicides which were applied before bloom if the after-bloom application was made also. Over a period of years, lime-sulfur proved to be the better fungicide for the control of mildew. The copper fungicides gave excellent control during most years, but during a dry season, they were not effective.

Lime-sulfur was not satisfactory in any of the tests for the control of leaf spot. Of 11 copper fungicides tested for leaf-spot control,

bordeaux mixture, 3–5–100, and Yellow Cuprocide, 1–4–100, both with S.E.C. oil, were the best. Two applications were necessary for efficient control. The first should be made about June 1 (about 2 or 3 weeks after bloom) to control the primary infection, while the after-harvest application will prevent secondary spread of the leaf spot. The sprays should be applied in such a way that a thoro coverage of the fungicide is obtained on both the upper and lower surfaces of the leaves.

Gooseberries are subject to copper injury and when copper fungicides are used, lime should be added to overcome the injury. The 3–5–100 formula for bordeaux mixture has proved satisfactory. If insoluble copper fungicides are used, 1 pound of lime should be added for each ¼ pound of actual copper that is present in the material.

Rust is generally considered to be of little importance since many plantings are not troubled by it. Yet, for those growers whose plantings are near the alternate sedge host, it can be a major disease problem, spoiling a high percentage of the berries and weakening the plants by early shedding of infected leaves.

The removal of sedge plants in the neighborhood of gooseberry plantings has greatly reduced the incidence of infection. Careful burning of the sedge fields in the fall or early spring also has given relief. However, where the sedge is growing in the woods or on adjacent property, the gooseberry plants may have to be protected by early applications of a suitable fungicide.

While both copper and sulfur fungicides proved to be effective in controlling the disease, the latter seem preferable because they are cheaper and also aid in mildew control. From the standpoint of avoiding injury, it is best not to use copper in the pre-bloom applications. Three applications of lime-sulfur, 2–100, starting at the green-tip stage of host development and ending just prior to bloom have given perfect control during 3 years of field tests. It is thought that some of the new organic fungicides, such as Fermate which has been shown to be much superior to sulfur in controlling apple-rust diseases, would give better protection from rust and perhaps fewer applications would be needed. However, Fermate is not satisfactory for the control of powdery mildew and leaf spot on gooseberries.

The most effective schedule for the control of the three major diseases of gooseberries as indicated by the results obtained would be four applications of lime-sulfur, 2–100, followed by two applications of bordeaux mixture, 3–5–100, plus 1 pint of S.E.C. oil. If only the powdery mildew and leaf spot were present, the data show that one

application of lime-sulfur followed by the two applications of bordeaux mixture would be sufficient. If only leaf spot occurred, the two applications of the bordeaux mixture were satisfactory. For rust, the three early applications of lime-sulfur, as previously mentioned, gave excellent control. If powdery mildew were the only disease present, a single application of lime-sulfur made immediately after bloom would be sufficient to give control. Various insecticides have been used at different times with the different fungicides with no deleterious effects.

A summary of the spray treatments which were found to be the most effective is given in Table 6.

TABLE 6.—SUMMARY OF EFFECTIVE SPRAY TREATMENTS FOR THE CONTROL OF GOOSEBERRY DISEASES IN NEW YORK STATE.

TIME OF APPLICATION	SPRAY TREATMENT FOR THE CONTROL OF		
	Rust	Powdery mildew	Leaf spot
Green-tip	Lime-sulfur 2–100		
Fourth spur leaf open	Lime-sulfur 2–100		
Before bloom	Lime-sulfur 2–100		
After bloom		Lime-sulfur 2–100*	
2 or 3 weeks after bloom			Bordeaux mixture 3–5–100†
After harvest			Bordeaux mixture 3–5–100†

*The addition of ½ pound of Spraysoy A improves coverage on leaves and fruit.
†The addition of 1 pint of S.E.C. oil or other suitable spreader-sticker improves coverage and gives better control.

SUMMARY AND CONCLUSIONS

The three major diseases of gooseberries in New York State are powdery mildew, *Sphaerotheca mors-uvae* (Schw.) Berk. and Curt.; leaf spot, *Mycosphaerella grossulariae* (Fr.) Lindau and *Pseudopeziza ribis* Kleb.; and rust, *Puccinia grossulariae* (Schum.) Lagh. Powdery mildew and leaf spot are generally prevalent thruout the State, while rust occurs in the Hudson Valley region.

In experiments conducted during the past 8 years, various concentrations of bordeaux mixture, 11 insoluble coppers, an organic fungicide, and two sulfur materials were tested for their efficiency for the control of powdery mildew, leaf spot, and rust. In general, the copper

fungicides were better for leaf-spot control, while lime-sulfur was best for the control of powdery mildew and rust.

Yellow Cuprocide, Basicop, and Tennessee 34 caused more copper injury to the foliage than did bordeaux mixture, Bordow, Copper Compound A, or Coposil. The copper injury was eliminated by increasing the lime in the bordeaux formula and by adding 1 pound of lime to the insoluble coppers for each ¼ pound of actual copper present.

As a result of spray tests it was found that the most efficient control of powdery mildew was obtained with one application of lime-sulfur, 2–100, plus ½ pound of Spraysoy A. This application was made immediately after bloom. Copper fungicides gave satisfactory control during most years but were not effective during a dry season.

The best control of leaf spot was obtained with two applications of bordeaux mixture, 3–5–100, plus 1 pint of S.E.C. oil. The first application was made about June 1, when leaf spot was first noticed, and the second in July immediately after the fruit was picked. Lime-sulfur did not control leaf spot.

Eradication of the alternate host of the gooseberry rust was the easiest and most economical way to control this disease. The sedge plants were removed or burned-over in the late fall or early spring. Spray tests have shown that for effective control of rust, three applications of lime-sulfur, 2–100, were required. The first application was made at the green-tip stage, the second about 10 days later, and the third just before bloom.

Powdery mildew and leaf spot were present in most gooseberry plantings. An application of lime-sulfur, 2–100, plus ½ pound of Spraysoy A, made immediately after bloom, followed by two applications of bordeaux mixture, 3–5–100, plus 1 pint of S.E.C. oil, the first about June 1 and the second after harvest, gave excellent control of both diseases during the 3 years the program was tested.

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